₊: Frontier



Request for prepurchase proposals

2024

Frontier is an advance market commitment to accelerate the development of carbon dioxide removal (CDR) technologies. We've facilitated <u>three rounds of prepurchases</u> since 2022 and are now releasing a call for applications for Frontier's next round of purchasing.

To support technologies at different stages of development, we have two purchase tracks: prepurchases and offtakes. Each track has its own eligibility criteria, diligence process, and funding amounts. The bulk of Frontier's spend will go toward offtakes, larger multi-year agreements with companies prepared to start scaling their technologies. However, we believe we have not yet seen the full scope of promising carbon removal approaches. Our prepurchase track is designed to support new companies in testing the most promising ideas.

This document is the request for proposals for Frontier's prepurchase track. As the first step in applying, please use the table below to understand our purchasing program and decide which track is the best fit for your company.

If you have any questions regarding the prepurchase program, please join our <u>purchase office hours</u> at 12 pm EDT on May 16 or May 24, 2024 or get in touch at prepurchase@frontierclimate.com. For the offtake track, go here.

	Track 1: Prepurchases	Track 2: Offtakes	
Summary	Low-volume prepurchase agreements to support early-stage suppliers piloting new technologies	Larger offtake agreements to support more mature suppliers preparing to scale	
Purchase amount	\$500K	~\$10M - \$50M	
Purchase structure	Paid upfront, before tons have been delivered	Commitment to buy future tons at an agreed price if and when delivered	
Frontier expectations and risk tolerance	Thorough diligence, higher risk tolerance than offtakes	More extensive diligence, lower risk tolerance than prepurchases	
Application cadence	Once-per-year purchase cycle	Applications accepted on a rolling basis	
Application deadline	Pre-applications due May 28, 2024	For consideration in 2024 and 2025, please express interest as early as possible	
	Expected status across evaluation criteria		
Performance data	There is lab-scale performance and preliminary stability data (preferably for days or more) showing proof of concept that the company's approach removes CO2 from the atmosphere.	Tech has been validated, preferably at or beyond small pilot scale, with data establishing performance and stability baseline. Roadmap defined for how the company will narrow gaps between current data and techno-economic analysis (TEA) assumptions.	
Monitoring,	Clear MRV approach outlined.	Company has a CDR protocol and is in	

reporting, & verification (MRV)	 For CDR pathways with lower verification confidence levels (VCLs), risks are identified and a method presented for how new data will be generated to reduce quantification 	 discussion with one or more credit issuers. Volume offered is discounted based on identified MRV uncertainties (if any) and we have high confidence in the ability to quantify volumes purchased.
Techno-economic analysis (TEA)	 A TEA based on a process flow diagram and mass and energy balance, using realistic engineering values (or similar) for equipment pricing, first principles estimates of performance, and basic assumptions for utility costs (format provided). 	 A high-fidelity TEA based on a pre-FEED design or similar, including a full process model. Key performance assumptions identified and validated with data. Ideally including quotes for major equipment, utilities, and O&M costs for specific locations. Confidence committing to a set price in a multi-year contract.
Ecosystem safety (e.g., impact to soils and oceans)	 Compelling case for why this CDR project does not cause additional ecosystem damage, based on experimental data and models. Company identifies potential risks and presents a plan to generate new data to confirm ecosystem safety at scale across early deployments. 	 Compelling case for why this CDR project does not cause additional ecosystem damage, based on experimental data. Ideally, the supplier has published ecosystem impact data and responded to feedback from the scientific community regarding potential risks. There is manageable remaining uncertainty around ecosystem impact, and company will actively manage deployments using appropriate ongoing ecosystem monitoring.
Community engagement	 Clear plans to collect input from stakeholders impacted by the project at early stages and to improve deployment based on that input. 	 Has proactively engaged stakeholders and revised deployment plans accordingly. Has or is developing a <u>community benefits</u> <u>plan</u> and an ongoing process to collect and act on community input.
Team and operational capability	 There is demonstrated expertise on the team for initial development work. Company has a hiring and/or partnering plan for other aspects of the project. 	 Company has experienced technical and commercial staff in place and project partners are identified and committed.
Business strategy & financing	 Key business case assumptions and risks identified. Preliminary plan established for next steps if the project is successful. 	 Company can define how the project fits within their strategy and the CDR market and policy landscape. Team has a credible path to securing financing and reaching a final investment decision. Company has supply chain, manufacturing, and risk management strategies.

Continue reading if you would like to apply for a <u>prepurchase</u>. If the offtake track is a better fit, please see our <u>offtake RFP</u>. If you're still not sure which track makes the most sense for you at this time, get in touch at <u>suppliers@frontierclimate.com</u>.

Frontier prepurchase track

2024 request for proposals

To apply for a Frontier prepurchase, please fill out the pre-application by May 28, 2024, after you've read this RFP.

The pre-application is a short form to help us understand whether your technology is likely to be a fit for this purchase cycle. We will pre-screen submissions and invite a subset to submit full applications with the goal of minimizing time spent applying by projects that likely don't meet the criteria of this RFP.

If you've submitted a pre-application in a prior cycle and want to reapply, please do! We know it's common for early-stage projects to shift directions and/or make rapid progress. In this case, please focus your response on *what's changed*.

If you have any questions, please join our <u>purchase office hours</u> at 12 pm EDT on May 16 or May 24, 2024 or email <u>prepurchase@frontierclimate.com</u>.

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1 | Timeline

	Step	Date
1	Companies submit pre-applications.	May 28
2	Frontier reviews pre-applications for basic eligibility against our approach criteria (e.g., 1000+ year durability, etc.) and fit to our innovation areas of focus defined below. We may ask for a short conversation to clarify any questions.	Early June
3	Frontier invites projects to apply (application writing period will be 3 weeks).	By June 7
4	Companies submit full applications.	June 25
5	Frontier reviews applications for completeness and basic scientific validity with respect to our criteria. Qualified applications are sent to external experts for scientific, commercial, and governance review.	Early July
6	Frontier sends anonymized expert review comments to applicants, who will have ~3 days to submit a short response to Frontier (if they choose to do so).	Mid July
7	Frontier may request a video meeting with applicants to further discuss their proposal.	Late July to early August
8	Frontier notifies applicants of prepurchase decisions.	Mid August
9	Frontier and selectees jointly build application-specific contract terms such as milestones.	Early September
10	Frontier announces prepurchase agreements.	Mid September

2 | How we evaluate projects

We look for permanent CDR solutions that have the potential to be low-cost and high-volume in the future, even if they're not today.

We use three lenses to make purchasing decisions:

- Approach: Does the CDR approach meet our target criteria?
- Execution: Can this team deliver on the proposal, given where the technology is today?
- Portfolio: Will this purchase help us build a diverse, risk-adjusted portfolio of CDR approaches?

Lens 1: Approach

Rigorous external scientific and governance assessment against Frontier's CDR criteria is the first and most critical qualifying step in Frontier's purchasing process. Section 4 presents a list approaches that do not meet one or more of the following criteria and are not in focus for our prepurchasing program at this time.

Criteria	Description
Durability	Stores carbon permanently (>1,000 years)
Physical footprint	Takes advantage of carbon sinks and sources less constrained by arable land
Cost	Has a path to being affordable at scale (<\$100 per ton)
Capacity	Has a path to being a meaningful part of the carbon removal solution portfolio (>0.5 gigatons per year)
Net negativity	Maximizes net removal of atmospheric carbon dioxide
Additionality	Results in net new carbon removed, rather than taking credit for removal that was already going to occur
Verifiability	Has a path to using scientifically rigorous and transparent methods for monitoring and verification
Safety and legality	Is working towards the highest standards of safety, compliance, and local environmental outcomes; actively mitigates risks and negative environmental and other externalities on an ongoing basis

Lens 2: Execution

We look for evidence that the team will be able to execute their proposed plan rigorously, quickly, and responsibly. The specifics of what we look for will vary based on the stage of the project, but generally we look for:

- **Technology readiness level:** Is the technology far enough along to make the proposal realistic/plausible? We typically look for an existing proof of concept (i.e., all major elements of the solution are at least at <u>TRL-3+</u>).
- **Team:** Does this team have the expertise and experience to deliver? This could include scientific, technical, operations, manufacturing, commercial, or regulatory expertise depending on the solution.
- **Delivery timing:** When will this project deliver first tons? We prefer earlier delivery (i.e., 2025/2026), even if it means smaller volumes. We rarely purchase from projects with no delivery for 3+ years.
- Past and expected learning rates: If this team has applied before, how much progress have they made since, and over what time period? Is this approach fundamentally compatible for fast iteration? How costly is each iteration?
- Ambitious but plausible and responsible scaling plans: We are looking for companies that move urgently, but also
 responsibly and realistically. For most approaches, this likely means increasing scale by no more than 10x per
 deployment, whereas for others, 100x might be acceptable if the applicant includes a justification for that scaling
 magnitude.
- 'Area under the curve': How high is the starting cost, and how quickly does it decline? If this approach has a very high starting cost, we'd expect it to have a particularly steep slope such that it's plausible the team can secure enough demand to scale and become competitive with companies who may be further along today.

Lens 3: Portfolio

We believe it will take a portfolio of CDR solutions and companies to achieve the gigatons of removal required each year. Frontier's goal is to build a risk-adjusted portfolio that maximizes the likelihood of that happening. This means that there is a possibility that even if a company meets our criteria, we may not make a purchase if, for example, we're over-indexed on that type of solution.

To give you a sense of how we have applied these lenses in the past, please take a look at prepurchases Frontier announced in <u>December 2022</u>, <u>June 2022</u>, and <u>September 2023</u>.

3 | Areas of focus for 2024 cycle

In addition to meeting our RFP criteria, we've identified a few areas in which we're especially excited to see more projects. Below outlines *general* focus areas and focus areas *by pathway*.

Overall

- Projects that leverage existing industrial assets or processes to scale carbon removal quickly and at lower costs. While startups have the advantage of being able to move quickly, large industrial companies benefit from existing infrastructure, assets and processes already operating at scale. Some of these resources could be repurposed or used for carbon removal. Promising opportunities include: increasing carbonation of mine tailings or using as an input for weathering; integrating enhanced weathering into existing agriculture operations; using alkaline byproducts from cement, steel or chemical production as carbon removal feedstock; incorporating removal into the briny waste from desalination; or integrating weathering into wastewater and desalination plants.
- Projects in APAC, the Middle East, Africa and Latin America. These are regions where we think there's
 significantly more potential for carbon removal projects than what we've seen to date.
- Projects that create redundancy across known, promising approaches. It's very unlikely that carbon removal will be winner-take-all given the scale required. Having several excellent teams working on the most promising approaches will increase the likelihood that the potential of any given pathway is realized. To that end, we'd be excited to see more world-class teams across a broader set of geographies working on (1) ways to durably store contaminated and unused organic waste biomass, and (2) approaches that use waste minerals for accelerated weathering on fields or in water streams rich in biogenic CO2 (such as rivers or wastewater treatment plants).
- Projects that can offer lower prices through additional revenue sources (e.g., energy co-products or monetizable
 co-benefits). Global carbon removal demand is not yet on track to support gigaton-scale. By offering carbon
 removal alongside saleable co-products or other revenue streams, projects can stretch carbon removal demand to
 create more resilient business models. Long-term as prices drop, these additional revenue sources (e.g., payment
 for enhanced weathering as an agricultural amendment or mineral addition at wastewater plants for pH
 management) may make carbon removal purchases unnecessary altogether for some projects.
- Projects that provide local environmental and economic co-benefits that build community and policy support
 (e.g., improving riverine health, remediating acidic or contaminated land/water, etc.). While we are laser-focused on
 the carbon impact of a CDR project, tangible, real environmental or economic co-benefits can generate local
 project support across constituents (e.g., farmers, labor unions, new industries, policymakers) and broader support
 for more ambitious climate action.

Enhanced Weathering

- Deployment conditions that further scientific understanding of optimal weathering environments (e.g., deployments in aqueous environments, hot and humid climates, non-agricultural settings, etc.)
- Deployment models that generate financial or environmental benefits at the site (e.g., reclamation, land/municipal development projects)
- Accelerating the weathering of alkaline minerals through biological (e.g., enzymes or microbes that help with rock dissolution), mechanical, thermal, or chemical treatments to liberate alkalinity from the feedstock

 Projects with clear feedstock strategies that could sum to an annual scale potential of >1Gt (e.g., copper waste from large mining operations, quarried feedstocks, and industrial byproducts like steel slag), including generalizable technologies that can use a variety of feedstock types

• Field weathering:

- Pioneering MRV methods to close the gap on outstanding uncertainties for the broader field (e.g., time lag
 of soil buffer pools, interaction with soil organic carbon pools, leakage through biological respiration, deep
 soil carbon fluxes)
- Teams with best-in-class logistics and the ability to effectively and efficiently deploy high volumes of feedstock (e.g., by leveraging existing feedstock sourcing or distribution infrastructure)

Marine CDR (mCDR)

• Site selection that enables measurement-based MRV, rather than relying exclusively on models, whether in ocean or inland-water environments

Mineral OAE:

- Projects with clear feedstock strategies that could sum to an annual scale potential of >1Gt (e.g., copper waste from large mining operations, quarried feedstocks, and industrial byproducts like steel slag), including generalizable technologies that can use a variety of feedstock types
- Methods for effective quantification of feedstock dissolution
- Efficient methods for treating or remediating feedstocks with dangerous contaminants so as to unlock more feedstock sources without compromising ecosystem safety
- Novel technologies for rapid mineral dissolution and/or pre-equilibration with atmospheric CO2

• Electrochemical OAE:

 Approaches that avoid the production of problematic byproducts (e.g., hydrochloric acid) altogether or offer creative solutions to managing them at scale

Direct Ocean Removal:

 Projects must demonstrate compelling paths to low-cost, for example through ultra-low energy requirements (e.g., reducing water pumping requirements, removing membrane contactors), valuable co-products, or cost-effective alternatives to geologic storage (e.g., pairing CO2 extraction from seawater with mineralization)

Biomass Carbon Removal and Storage (BiCRS)

- Solutions that maximize carbon permanently stored (i.e., CO2 efficiency) and energy co-benefits (e.g., avoided
 emissions through the creation of energy coproducts like H2 or the use of biomass that avoids methane release)
 while minimizing biogenic emissions and nutrient export from biomass
- Modular approaches that can accommodate smaller sources of biomass while remaining economical and efficient, or that capitalize on novel and abundant waste streams (e.g., wet, contaminated, etc.)
- Approaches integrating with industrial waste systems (e.g., municipal solid waste, sewage sludge) for direct
 injection; conversion to heat, electricity or hydrogen; hydrothermal liquefaction; and/or solutions that can capture
 and store CO2 cost-effectively at smaller scales (e.g., on-site storage and alternatives to geologic injection)

Direct Air Capture (DAC)

- Projects able to use and/or procure energy efficiently and effectively (e.g., flexible operation to match clean power generation, use of waste heat or heat pump technology, integration with clean, firm power/heat generators like geothermal and nuclear, or integration with behind-the-meter renewables and energy storage, etc.)
- Projects integrated with alternatives to geologic storage (e.g., in-situ or ex-situ mineralization)
- To be competitive with existing players, novel projects must demonstrate ultra-low energy requirements and/or have compelling plans to scale and reduce costs faster than the existing players

4 | Out-of-scope approaches

This table is not meant to be exhaustive, but based on our learnings thus far, we do not consider the following CDR approaches in scope for this prepurchase cycle:

Out of scope approach	Rationale
Afforestation and reforestation	
Coastal restoration and Blue carbon	Unable to meet Frontier's 1,000 year durability threshold
Organic soil carbon	
Shallow biomass burial	Frontier supports several companies accelerating research across these approaches. However, given their ongoing work, particularly to address questions around reversal from site disturbance (burial) and durability (sinking), further purchases are not a priority for this RFP.
Terrestrial biomass sinking	
Biochar	While certain treatment methods can produce char that meet our durability criteria, we are prioritizing other BiCRS approaches with higher CDR efficiency.
Biotic marine CDR	There are open questions around the ability of micro- and macroalgae capture approaches to meet Frontier's scale and durability criteria while minimizing impacts to ocean ecosystems.
	Note: Biotic mechanisms that result in abiotic storage (e.g., biomineralization) remain <u>in-scope</u> .
Storage partners without a capture partner	Novel, high durability storage solutions are critical to scale CDR across diverse geographies, but we are looking for projects that are coupled with capture in an "end-to-end" system. We will not consider storage-only applications this cycle.

5 | Other considerations

Transparency & confidentiality

If you are invited to submit an application and do so, please be aware that a portion of your application, including project description, high-level cost summary, and measurement approach, will be made public at the conclusion of Frontier's purchase cycle. We do this because commercial-scale permanent CDR is developing, and we are trying to advance transparency and knowledge-sharing across the ecosystem as it does. Hopefully this will enable impact beyond the dollar amount of any particular purchase we may make.

Examples of what information will be published can be found in our 2023 Summer applications published on our <u>GitHub repository</u>. This is in contrast to our 2022 prepurchase cycles when we published each prepurchase application in full.

In the application template, we will clearly specify for which questions we will publish applicants' responses. The rest of the application information will remain confidential among Frontier staff and our expert review team, who have non-disclosure agreements in place with Frontier. This includes a techno-economic spreadsheet that we will ask all applicants to fill out.

Communication

All communication related to Frontier's 2024 CDR purchasing cycle should be sent to prepurchase@frontierclimate.com.

Supplemental information

- Introducing Frontier
- Purchasing Q&A
- Frontier GitHub source materials (applications, contracts, templates)